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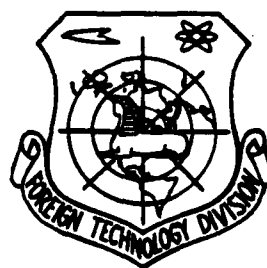
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# FOREIGN TECHNOLOGY DIVISION



AERONAUTICAL KNOWLEDGE  
(Selected Articles)



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PREPARED BY:  
TRANSLATION DIVISION  
FOREIGN TECHNOLOGY DIVISION  
WP-AFB, OHIO.

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## IMPRESSIONS OF JAPAN'S SPACE TECHNOLOGY

by Ren Xinmin

Japan developed its space research later than the United States and the Soviet Union and the strength of this research is also far inferior to that of the latter two. However, due to the great strength of Japan's basic industries, the basic and advanced research work in the field of space has developed well. They are especially adept at using the advanced technology of other nations and because of this the pace of Japan's space activities has been very fast.

Japan was the fourth nation in the world to launch a man made satellite and was the third nation, following the United States and the Soviet Union, to independently launch a synchronized orbital motionless satellite thereby giving Japan a great deal of space research and technical experience data. Within a short period of time, Japan has gradually established and perfected a space organization, trained a technical contingency for space research, set up relatively complete large scale ground testing facilities, established sophisticated satellite launching fields, ground tracks and

data handling networks, and developed its satellite applied research. This has acted to continue to develop a solid foundation for Japan's space technology.

The author has had the opportunity to visit the Tokyo Space Science Fair as well as related space technology research organizations and companies. Below are some impressions I had on the development of Japan's space technology:

1. It has advanced sequentially from the small to the large on a solid path. In 1955, when Japan began research on sounding rockets the scale was very small. There were only a small number of professors from the Tokyo University of Science and Engineering who participated in the International Geophysics Annual Preparations from 1957 to 1958. The development of the first model called "Pencil" was as the name implies a long and thin single stage solid rocket. In 1958, they successfully developed a K 6 two stage sounding rocket. In the last twenty years, there has been no interruption in Japan's work on developing and employing sounding rockets whereby they have successfully developed the two series of K (Kappa) and L(Raboda\*) and on the basis of the solid sounding rocket

\* Phonetic transliteration

successfully developed the M series solid transport rocket. The greatest thrust of the solid engine single stand was 109 tons and with 8 booster rockets the take off thrust could reach 140 tons. It could send an effective weight of 270 kilograms into a circular orbit 250 kilometers from earth. At present, the solid sounding rocket has attained to extensive use in Japan. Tokyo University, on an average, annually launches ten research projects on outer space and Japan's meteorological office just about every week launches a meteorological rocket. Japan's South Pole Exploration Party on an average annually launches about ten rockets. They have already used the M series solid transport rocket to launch nine satellites with only one failure. The rate of success has reached 89 percent. This shows that Japan has already gained strong achievements in its development of solid rocket technology.

2. From the simple to the complex they have developed the new, strengthened the old and used various methods to carry out space exploration.

The use of balloons to carry out space research is a relatively primitive method yet Japan has never abandoned this sphere of research. At present, Tokyo University already has various hydrogen balloons from 5,000 to 200,000 cubic meters

and has just developed a 500,000 cubic meter giant balloon. When balloons are used to carry out atmospheric research there are the advantages of a long time lapse (up to 80 hours), the instruments can be recovered and the cost is low. Each year Tokyo University launches 20 balloons with the longest distance reaching 1,100 kilometers. Using this type of method, successful research has been carried out on solar neutrons, initial cosmic rays, solar infrared radiation, cosmic x rays, the explosion of gamma rays and the ionospheric and ozone layers of the atmosphere.

In developing scientific satellites, based on the fact that the demands of orbital precision and orbital parameter for the satellite are not very high, Japan brings into full play its solid rocket technology. The satellites launched by the Tokyo University Space Aeronautics Institute always use M series solid rockets. Their guidance schemes are very simple such as the three scientific satellites "Green Blue No. 1", "New Star" and "Electric Wave" which use M4S rockets. Their first and second stages, besides the aerodynamic stabilization wings, do not have guidance systems or control mechanisms. Their third and fourth stages use spin stabilization. For the entire rocket, only in the third stage is there a position control system. This is used to regulate the flying position when the third stage burns out, so that the rocket's angle of



pitch satisfies the demands of entering an elliptic orbit revolving around the earth and guarantees that the satellite will enter its orbital path. The M rocket which is obliquely launched uses status datum equipment on the rocket and on the ground has an integrated program of radio guidance to launch the satellite. Although the orbital precision is not high, yet the rocket's equipment is simple and so is economical and dependable. Japan, while striving for substantial results in the field of space technology has already opened up new spheres and furthermore exploited the potentialities of already existing technology.

3. They have paid attention to preliminary and basic technological research. Space technology is established on the foundations of the level of modern science and industry. The stronger the foundation becomes the more the calibre of the products advances. Japan's space technology has developed rather quickly and one very important reason for this is its adeptness in paying attention to applicable technological reserves. For example, used in the second and third a rocket it raises the carrying capacity of the liquid hydrogen and liquid oxygen engine and it can be used to regulate an ion rocket engine of a synchronized satellite orbit. These have now all been considerably advanced. Other cases, such as the use of metal as a basic fiber to strengthen

compound materials and carbon fiber materials, can substantially raise the function of the product's structure which has already been extensively researched and reached a functional phase.

These projects have laid a foundation for the further development of space technology. In fundamental technology, taking environmental simulated test apparatus as an example, in 1963 Japan sent out a specialized observation group to investigate the American space navigation environmental tests and domestically have also launched a great deal of development work. At present in Japan, besides the two important space technology research branches of the Space Development Organization's space center and the Tokyo University Space Navigation Institute equipped with relatively perfected environmental test series, other specialized departments and contract companies based on their own work have established various differing environmental simulated equipment. This is also an important factor in the relatively smooth development of Japan's transport rockets and satellites.

4. They have imported foreign technology and extensively developed international cooperation.

In space technology, if we say that solid rockets were developed by the Japanese themselves, then the basis of liquid

rockets began on the foundation of the American Delta transport rocket. The core structure of Japan's space exploration, the "Space Development Organization", was set up in June of 1969. After its establishment, Japan developed applicable research on the size, weight and orbit of satellites and thought that the most economical and fastest method was the importation of American rocket technology. Soon after negotiations with the United States, they imported the reliable and economical Delta transport rocket\*. In December of the same year, the United States approved the export of technology to Japan. The N 1 rocket now utilized by the Space Development Organization was established on the foundation of the importation of Delta technology. Some components were even ready made products from the United States or produced in the United States. Of course, the importation was not completely imitation, as the components of the N 1 and especially the N 2 rockets, such as the engines for the second stage, were developed in Japan.

Furthermore, in the 1970's Japan first began developing meteorological satellites. At this time, they were confronted with the problems of resolving the satellite's application of

\* The Delta transport rocket has already successfully launched over 100 satellites. Its rate of success is high and is internationally called "the efficient horse",

various equipment and being able to send the transport instruments of this 350 kilogram satellite into a synchronized orbit of 3,600 kilometers. After research, Japan temporarily decided to postpone the latter and changed to negotiate with the United States so that in July, 1975 they signed a contract with the United States and paid 48 million American dollars. In 1977 and 1978, Japan was sent meteorological, communications and direct transmission satellites from the United States. Now these three satellites have already, according to plan, been sent into orbit and after being tested and utilized by Japan have greatly enhanced Japan's meteorological scientific research which has reached an international level of telecommunications and television transmission.

5. In Japan we had seen these types of slogans: "Today's quality control is tomorrow's success", "The foundation of space development is trustability", "Advance towards mighty factories" and "To leap towards tomorrow do your present work well". If these slogans are not based on reality they will have no significance. The places which we visited, whether they were science administration departments, research centers, production factories, launching fields or testing stations, all were quiet and clean. The interiors were spotless, tidy, had soft tones and suitable temperatures. On the outsides there were pruned gardens and clumps of trees. For example, in the well

known Japanese enterprise Fukushito, cleanliness, necessary equipment, convenience in work or comfort and beauty were all first rate. We also visited a precision bearing factory and as soon as we entered the shop we faintly heard the sound of music coming from some unknown place. Those in charge said that in this type of environment the workers did not become tired easily which could guarantee product quality.

We also came to understand that the Tokyo University Space Navigation Institute including its three land balloon centers, capability center and the Kajishima Space Center had about 500 persons. The Kajishima Space Center had 66 constructed buildings and each year, except for the launching periods during February, August and September, it is authorized to have only 21 persons. The Tanagashima Space Center, a subsidiary of the Space Development Organization, the core structure of Japan's space technology, only had a hundred odd persons. The Chikubo Space Center only had 126 persons (during the launching periods they borrow personnel from the outside) responsible for the large scale testing of satellites and transport rockets, following the path of a satellite after it is put into orbit and measurement control. Because of this, Japan's space technology gives one the impression of raised efficiency and meticulous quality. The creation of civilized production and tidy scientific research are necessary to

gaurantee the development of space technology.

Title chart by Wang Xiaofei

## THE INFRARED SCANNING PROBE TECHNIQUE

by Zhou Yanru

In the early morning the sun rises in the east casting light and energy on the earth providing light for people and life to all things on earth. There are infrared rays within the solar ray spectrum which hits the earth. Not only the sun emits radiation infrared rays but all substances in the natural world with temperatures above absolute zero (minus 273 degrees centigrade) emit radioactive infrared rays. It is thus clear that infrared rays are with us and that every second we come in contact with them. It is only that we cannot see or touch them.

Infrared rays and visible light are the same. They are part of the electromagnetic spectrum and the range of its wavelengths is within 0.75 to 1,000 microns (chart 1). This broad infrared area is usually divided into three sections: those with wavelengths of 0.75 to 1.5 microns are called near infrared rays; those with wavelengths of 1.5 to 5.6 microns are called middle infrared rays; those with wavelengths of 5.6 to 1,000

microns are called distant infrared rays.

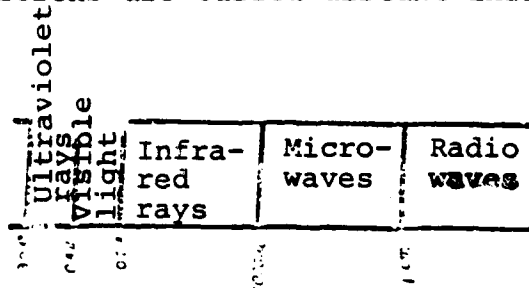


Chart 1. Electromagnetic Spectrum

Infrared rays were discovered very early and their use has already been extended to the fields of production, livelihood and military affairs. The distant infrared ray heating technique is a new heating technique that has been developed within the last few years. It saves energy and shortens baking time which is an important technological innovation that has been popularized and stressed in China. In the same way, in recent years the infrared remote sensing probe technique has quickly developed and is an important tool for mankind to probe and exploit the natural world. Round the clock satellites



revolving around the earth, military reconnaissance planes and certain specialized air mapping planes are fitted with infrared probing instruments. The infrared probing technique has already caught people's attention and is a rising science with a developing future.

### The Principle of Infrared Probing

Can invisible infrared rays be changed so that people can see them? Yes, and we must rely upon the infrared probing technique. A camera is fitted with a red filter lens which uses a specially made infrared sensitive film and when a picture is taken of the infrared image of the object's reflection an infrared picture can be obtained. Unfortunately, this method can only take pictures of infrared images whose wavelengths are within the 0.75 to 1.2 micron range. These approach the visible light infrared spectrum and are called near infrared pictures. In order to extend the sphere of the pictures we can use a scanning technique to change the larger wavelength infrared rays so that pictures can be examined with the naked eye. These are commonly called infrared heat pictures.

Chart 2 shows the principle of infrared scanning for creating pictures. Each of the object's radiating infrared rays on the scanning lens perceived surface, after optical system

focusing, are changed by the ingrared probe into telecommunications signals and having been enlarged by the amplifier, the electric light transformer again scans the sensitive film making it an infrared heat picture visible to the naked eye. Some instruments, after the telecommunication signal has been obtained from the infrared probe and been enlarged, directly record it on magnetic tape and afterwards it is sent to be handled by an electronic computer and based on different requiremments is transformed into pictures or graphs.

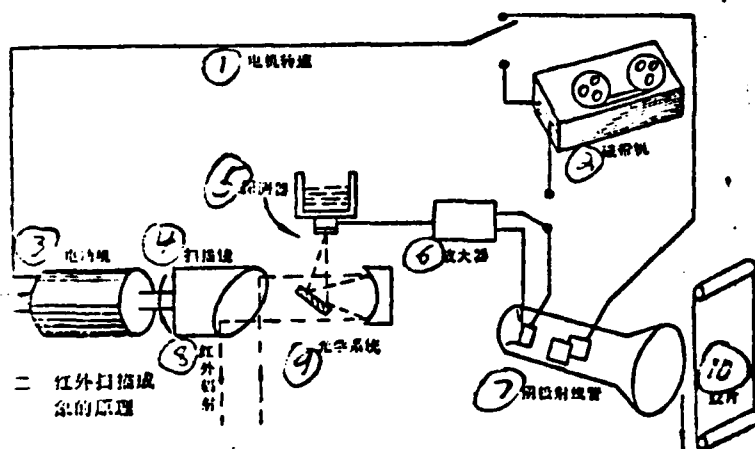


Chart 2 Principle of Creating Pictures by Infrared Scanning

Key: 1) electrical rotational speed, 2) Magnetic tape recorder, 3) motor, 4) scanning lens, 5) probe, 6) amplifier, 7) cathode ray tube, 8) infrared radiation, 9) optical system.

How is aerial infrared scanning work done to create pictures? It does not resemble the common areal camera carried in airplanes that depends on fixed time intervals to shoot continuous pictures one by one, but is similar to the television. It follows the surface features with the rotation of the scanning lens scanning one point at a time to create a scanning line. Afterwards, it again follows the continuous shifts of the plane and negatives so that it scans the surface and sensitive photographic plates line by line. Finally, it obtains a continuous long photo.

How can an infrared scanner expose the image of the surface object on film? This is possible because in each instant of scanning, the scanning lens only receives the visual field's infrared radiation on the appropriate surface. The radiation frequency of the substance and the size of its radiation energy then create a direct ratio with the absolute

temperature. Due to the radiation properties of the various substances and the differences in temperature, the radiation energies are dissimilar. Therefore, after the light/electricity/light changes, the amount of exposure on the sensitive film is also dissimilar. When the temperature is high, the substance with strong radiation properties can show a bright tone on the photo, but on the contrary reveals a dark tone. When the infrared scanning technique is used during the day or at night it always attains to the principle of images.

#### Special Characteristics

When people take photos it is necessary to have light rays and then the negative can be exposed. Infrared scanning to create pictures is not limited to visible light and it is not only during the day that pictures can be created by scanning but in the black of night when one cannot see his hand in front of his face photos can also be obtained. At the same time it can also show military camouflage, particular industrial facilities such as stored oil tanks, steel rolling shops, thermoelectric stations, underground hot water ducts and even mineral resources or geological structures. In addition, infrared scanning to create pictures is not very demanding for weather condition requirements so that under conditions of mist and smoke pictures can be created by scanning. However,

under conditions of dense clouds and heavy fog pictures cannot be made. The above mentioned advantages are too inferior to bear comparison with visible light photos.

Why does infrared scanning to create pictures have such great capabilities? As mentioned previously, what is received by the infrared probe is not a projection of solar rays but is the electromagnetic wave projected by the substance itself which is heat radiation. This type of radiation is not limited by illumination conditions or the conditions of season or weather. There are many differences among the various substances in the natural world as reflected in the infrared scanning photos which are thermographs of temperature changes. This type of temperature cannot be seen by the human eye but can only be observed with the aid of infrared scanning photos.

Aside from the above mentioned advantages, infrared scanning to create pictures can also allow the transmission, recording, analysis and handling of information to become automated and digitized the same as the images on a videocorder. For the information from the infrared probe recorded on a high density magnetic tape, during the required time it must always pass through a computer which transforms it into images. This is not only convenient for preserving but also beneficial for maintaining secrecy. Although the advantages of infrared

scanning pictures are many, still it cannot be totally substituted for visible light pictures. Its space resolving power is relatively low which is to say it cannot attain the clear, fine images of light photos. At the same time, the distortion of its geometric form is relatively great and at present we still cannot use it to make a chart. Therefore, when analyzing the photos, we must still fully utilize their individual strong points and use both the infrared photos and visible light photos for comparison and comprehensive analysis. Then we will be able to attain even better results.

#### Conditions of Application

The present application of the infrared scanning probe technique can be divided into two categories: one is its installation in satellites which is called the satellite carrying probe technique; the other is its installation in planes which is called the plane carrying probe technique.

The satellite carrying probe technique is used for military reconnaissance satellites, air defense prealert satellites, meteorological satellites and earth resource satellites. All of these satellites are equipped with various infrared probing instruments. Among them, some carry out military reconnaissance activities and some are used to research and exploit the earth's

resources. Their use has been completely expanded. This article only introduces the application of the plane carrying aerial infrared probing technique.

As soon as one mentions airplanes, people usually think of their use for fighting, transport, reconnaissance and lifesaving. But if they are equipped with infrared probing instruments it is like clearing up a case of pinkeye. When people discover this previously unknown world, its use can become even greater in each sphere of the people's economy.

Agriculture and Forestry. We can use aerial infrared scanning for forming pictures to keep a watch on forest fires, to classify trees and to guard the growth conditions of agricultural crops as well as plant diseases and insect pests that occur. It can also be used to research the moisture content of farm soil and at the same time discover ditch leakage so as to conduct irrigation at the proper time and strengthen farm administration.

Hydrology. It can be used to carry out regimen surveys such as of the distribution of rainfall, water permeation and evaporation, the area of accumulated snow and the changes in the movement of glaciers, and for flood forecasts and the charting of floods.

The Survey of Water Resources. Aerial infrared scanning to create pictures can quickly obtain hydrogeological data by carrying out research on surface water and making hydrogeological charts. It is especially applicable in hydrogeological work for developing relatively deficient remote areas or passage through high mountain ridges and deep gorges. In arid, semiarid and karst areas it can be used to seek shallow layer ground water. It is especially effective for seeking fresh water springs in island and coastal areas where fresh water is in short supply.

Oceanography. It can be used to determine the position of the coastline, to research the changes in the coastline and the changes of river mouths and sand deposits, to seek the demarkation of fresh water and salt water, to research the distribution of icebergs, to keep a watch on icebergs and to discover ocean currents. It can also be employed to **probe for the** shoal of fish and carry out research to discover fishing grounds and marine plankton.

Geological Mapping. In geological structure research and mineral surveys, the application of infrared scanning photos can be used to differentiate particular rocks which are not easily distinguished in visible light photos and it can also be used to differentiate rocks and lithofacies and for geological



mapping. For the seeking of faults, the discovery of larger hidden cracks and certain anticline and syncline structures, without exception it has the unparalleled excellence of visible light photos. Furthermore, it can also, based on research of geological structure and geomorphology, indirectly indicate oil and distant areas where placer deposit beds exist. It can also be used to directly discover underground combustible or above ground coal beds and radioactive mineral deposits and vulcanized mineral deposits.

Geothermal Surveys. The earth is a huge heat storehouse and when terrestrial heat circulates and comes near the earth's surface or appears on the earth's surface then it becomes a geothermal resource that can be use by man. Infrared scanning to create pictures is particularly effective for seeking trapped underground hot water and heat.

Other cases, such as keeping a watch on environmental pollution in cities, the seeking of hard to find boats, keeping a lookout for volcanic activity and forecasting earthquakes can all use the infrared scanning probe technique. China has already begun aerial infrared scanning probe tests in geology, hydrology, agriculture, forestry and fishing. We believe that the infrared scanning probe technique can certainly play a role in making the investigation of natural resources greater,

faster, better and more economical in China.

Title chart by Tian Chungeng

Insert charts by Zhang Xiaoli